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ABSTRACT

This paper describes the joint collaboration of Broome Community College (BCC) (New York) and the State University of New York at Binghamton to help their engineering students become self-directed learners (SDL). Gerald Grow's model for staged self-directed learning is presented as a framework for the collaboration, with its four stages of student ability: (1) dependent; (2) interested; (3) involved; (4) self-directed. At each level, the role of the instructor complements the student's ability. To optimize the student's learning and promote development of SDL skills, a course needs to start where the student functions competently and then stretch them through activities that call on more active, independent learning. Self-directed learners, when confronted with a new topic which they need or want to learn, are capable of setting educational goals, establishing a program for learning the desired information/skills, adapting the learning program to their preferred learning styles, and evaluating their own level of achievement. At BCC, training in SDL skills is being built into second-year traditional, as well as asynchronous, courses through use of group projects. Binghamton integrates instruction in communications, computers, graphics and design, and provides a natural platform for developing SDL skills and attitudes. Joint development and the sharing of experiences has assisted both colleges in this project in building more effective programs and more self-directed students. (Contains 18 references.) (JA)

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SELF-DIRECTED LEARNING: A 2-YEAR, 4-YEAR COLLABORATION FOR ENGINEERING STUDENTS

by

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Self-Directed Learning : A 2-Year, 4-Year Collaboration for Engineering Students

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Introduction

Every study of engineering education and the skills required of practicing engineers lists life-long learning (LLL) as a necessary ingredient. And yet, there has been little developed in the way of formal preparation for engineering students so that they will become life-long learners. In fact, the loaded curriculum presented in most engineering programs works against developing the learning skills and love of learning required to be a successful LLL. Students do not have time to reflect on what they are learning or to explore personal interests through elective courses while in college. The seeds of effective LLL must be sown at the beginning of the program if the college experience is going to support this type of development in engineering students. In an earlier paper we how we started students on the path toward becoming self-directed learners (SDL).[1] This paper describes the next step in our joint collaboration in this effort which involves an (SDL) program in an asynchronous learning (ASL) course at Broome Community College (BCC) and the State University of New York at Binghamton. (SUNY-B).

Both colleges are units of the State University of New York located in Binghamton, New York. BCC has an engineering science program designed for transfer students and the Watson School of Engineering at SUNY-B serves the needs of those transfers. The two colleges have a history of collaboration in the area of engineering education.

Self-Directed Learners

A successful program for teaching SDL must have two components. First, it must *motivate* the students to aspire to be self-directed learners. This is not easy. In the traditional program, the instructor assumes responsibility for organizing the learning, defining what is to be learned, and assessing the success achieved by each student. All the student has to do is show up and do the work. The reasons for developing the SDL skills must be made explicit, using terms that the student can understand and accept. Second, the program must structure the development of the *critical skills* for SDL in order for the students to master them, practice them, and adopt them as the natural approach to learning any new topic.

Self-directed learners, when confronted with a new topic which they need or want to learn, are capable of setting educational goals, establishing a program for learning the desired information/skills, adapting the learning program to their preferred learning styles, and evaluating their own level of achievement. They have the motivation and discipline to work through the difficult stages of learning and can use a variety of resources, as needed, to help them master the material. In other words, they are mature learners. Indeed, there is a wealth of material in the adult education field describing SDL.[2] Phoenix University, which is strictly ASL, only admits students who are 28 years or older. Our special problem is that most students entering engineering programs are "traditional" students, (approximately 18 years old and a recent high school graduate) willingly dependent upon the instructor to direct their learning.

A Model for SDL

Gerald Grow[3] has presented an useful model for staged self directed learning (SSDL) based on the Situational Leadership Model of Hersey and Blanchard[4]. They state that management should be situational or matched to the employee's readiness. Readiness - a combination of ability and motivation - ranges from "not able" and "not willing or motivated" to "able and willing". Good instruction must be formatted so that the intellectual challenge is appropriate and the context is relevant to the student's life experience. Grow describes four stages of ability in the SSDL, ranging from Dependent (stage 1) to Self-Directed (stage 4) At each level, the role of the instructor for optimum match with the student changes. This is illustrated in Table 1(end of paper).

Grow states that there is nothing wrong with being a dependent learner - one who needs to be taught, but it is limiting. In some cases, stage 3 or 4 learners may become dependent in certain situations where it is temporarily advantageous. The ability to be self-directed is situational: one may be self-directed in one subject, a dependent learner in another.

Furthermore, the self-directed learner will frequently work collaboratively with other learners or specialists. The difference is that the Stage 4 learner assumes responsibility for designing the learning

situation, where the Stage 1 learner is dependent upon the teacher to do that.

Matching a Course to the Student's Stage

To optimize the student's learning and promote development of SDL skills, a course needs to start where the student functions competently and then stretch them through activities which call on more active, independent learning. The importance of matching the educational challenge to the student's level is a recurring theme in our studies [5,6,7] of how to optimize learning in lower division courses. In his nine-step model of intellectual development in college students, Perry[8] states that students can only understand concepts that are one step beyond where they are functioning. Goleman's book on emotional intelligence describes optimum learning occurring when the student is in "flow", where the challenge is just about achievable and there is total concentration on the task.[9] Conversely, when emotions overwhelm concentration, what is being swamped is the mental capacity cognitive scientists call "working memory," the ability to hold in mind all information relevant to the task at hand. And yet, all three authors - Grow, Perry, and Goleman - are promoting the development of higher levels of functioning, moving toward autonomy, where the learner is in control. The mark of the master teacher is to identify where the student is and provide optimum challenge to move them to a higher level of learning performance. This can be done effectively when working with graduate students on a one-to-one basis. It is a major challenge when facing 100 freshmen with widely varying levels of learning skills and academic preparation.

Preparing Engineering Students for SDL – Stage One

The primary challenge to the entering 18 year-old college freshmen is survival - social, emotional, financial, and academic survival - probably in that order. It is understandable that, in the high-risk environment in which they find themselves, they seek a highly structured learning environment where the instructor tells them exactly what is needed and there is no ambiguity. In this environment, activities to start building SDL abilities must deal with the immediate needs of the student. Collaboration with other students through cooperative learning, team projects, and study groups is an example of a basic skill required of the self-directed learner, because Stage-4 learners make effective use of colleagues and experts to meet their educational goals. For the freshman, the social need to meet other students and the academic need for an instructional support group lead naturally to building teaming capabilities.

The other immediate need is to know "how am I doing?" Helping students begin to assess their own performance and that of their peers moves the evaluation responsibility off the shoulders of the instructor and on to the students'.

The third component of building SDL is to help students identify the basic learning skills required for academic survival. These include time management and effective learning skills - the ability to take notes, read a technical book, prepare for an examination and produce logical, intelligible homework. A desirable adjunct to this is to help the students assess their preferred learning styles, both understanding how they absorb information and how they interact with instructors and other students.

Once students have laid the groundwork for SDL, they are ready for Stage Two of our SDL program, which involves having students begin to design their own learning program and assume responsibility for its implementation.

Preparing Students for Stage Two – Broome Community College

This is already occurring at Broome Community College (BCC) in second year courses being offered in Engineering Mechanics (Statics and Dynamics), Strength of Materials, and Engineering Design (III and IV). While we can justify the development of SDL capabilities in students as preparation for their professional careers, as asynchronous learning (ASL) becomes more widespread, the SDL skills will be needed for a student to survive in college. Successful ASL courseware has been developed elsewhere for use in graduate courses for practicing professionals, where the motivation and maturity are in place for a successful learning experience. But now we are seeing the introduction of ASL courses in community colleges and lower-division four-year courses where they will challenge the students to take charge of their learning in a way never required before. ASL courses will be needed by small colleges with engineering science programs to provide the specialized elective courses required by engineering students preparing to transfer to a four-year program. Our experience over the past two years has been that the retention of students in ASL courses is very much a factor of age and maturity. Of those under the age of 25 starting one of the ASL courses, 48% completed the course, while the completion rate for those over 25 is 84%. Clearly, the inclusion of SDL activities was needed in order to improve the retention.

At BCC, training in SDL skills is being built into second year traditional, as well as ASL, courses through use of group projects. At the beginning of the semester, the students are responsible for setting up teams. The teams, in turn, are responsible for

developing the grading policy and project materials, reporting on team projects, and assessing other teams. Students also individually assess their team member's performance and their contribution to the team. To accomplish this, students must develop writing, speaking and evaluation skills, similar to those used by practicing engineers.

Past experiences with team projects of this magnitude were that most teams simply got lost during the semester and never really worked well until it was too late for them to produce a significant solution to a problem. Further, the solution was "last minute" and never allowed time to reflect on the team's design and the need for modification and/or improvement. Using a traditional student journal allowed an opportunity to see a student's perspective about the class, but did not really enhance the development of SDL capabilities. In the Spring of 1999, a frustrated ASL student in Engineering Dynamics asked for the development of a tool that would facilitate the "teams" effort and success while working on the group projects. The "tool' that evolved is a "Group Journal" integrated into the group projects. Its application is described with respect to an engineering design class but has been used in both Statics and Dynamics as well.

Engineering Design III at BCC is a one-credit, three-hour laboratory format class offered in traditional and ASL mode. The course is a required core curriculum course usually taken in the 1st semester of the 2nd year. Although formal instruction is presented on the "design process" using a traditional design text, most of the class focuses on two class projects that require considerable development of SDL skills to be completed successfully. Although, the topics for the projects vary, the overall themes require a "paper" application of the design process to a biological science field and a "working model" that requires an integrated application of electrical/mechanical systems at the appropriate level for 2nd year engineering students. Both projects are assigned at the beginning of the class, with overlapping deadlines for component submissions. Assessment tools that will be used during the course are available and presented the first week of class. Web pages that are used to describe the course organization and the process for weekly reporting are illustrated.

Detailed tasks are then outlined for the semester with specific deadlines and information required for submission. Students in each class are at different levels of SDL skill development and may have different preferred learning styles. As a result, on the first day of class, each student reads the tasks and develops expectations based upon their SDL level and preferred learning style. This usually means that although most students will have good intentions of completing the tasks, they will not be successful because they have not developed sufficient SDL skills from their 1st year instruction. They are beginning "interested learners" but still possess many "dependent learner" characteristics.

The Group Journal establishes a powerful mechanism to promote team success. It provides a necessary tool to help communication between team members and a means for keeping members on task. All e-mail and telephone numbers are in one place. Excuses about not knowing how to contact another member of the team are eliminated. Assignments from the instructor are placed at the top of the form. Assignments made by the team for individual members are recorded on the form. Teams record weekly attendance of members. Teams assign contribution grades for the week's work on the form. Individual assignments for the next class are also on the form. This working document keeps teams on task and provides critical information to the instructor about the team's progress. The team e-mails the Group Journal to the instructor and all members of the team just before the end of the traditional class. In the case of ASL students, it is sent on Sunday evening as a summary of the week's activities.

The first week of class, most teams do not successfully complete the Group Journal and need considerable coaching. Also, most assignments of individual grades are usually inflated until the team realizes that a member is not performing their fair share of the work. It is at this time, that peer pressure has a real motivating effect on the non-productive student.

Based on that experience, Beston, at BCC, developed CST 106: Computers and Technology, for presentation over the Internet starting in the Spring of 2000. This course was developed for the student interested in engineering or engineering technology that has little or no computer expertise, but would like to take advantage of the flexibility that ASL offers compared to traditional seat-based instruction. Learner-centered instruction includes student journals, group projects with papers submitted and group presentations. The course focuses on applications that requires the use of a software package, rather than on the software itself. As in the design course described above, student-oriented instruction includes assessment of individual performance and team evaluation of group projects, as well as self-evaluation on projects and the course. Self-management skills imbedded in the class include such topics as: time management, goal setting, effective learning strategies, information retrieval, and preferred-learning assessment. This course is intended to be the first step in developing computer

and SDL skills necessary to move the student from a teacher-directed learning environment to a self-directed learning environment.

Based on 30 years experience of teaching FORTRAN" and other introductory programming courses, Beston wanted to make sure that the quality of the course was not compromised because of its delivery mode. Tools were developed which could be used in a traditional seat-based section, including student journals, group projects with papers submitted, group presentations, quizzes, and a number of modules that would help students to be successful self-directed learners. As in the design course, student-centered instruction components were to include the assessment of individual performance and team evaluation of group projects, as well as a self-evaluation in the course. Effort was taken to make sure that this course was not the usual "push this button and see what happens" class that is commonplace in introductory computer programming classes. Rather, the course focuses on student projects and the development of tools and skills that are needed for the student as a life long learner.

Fifteen units were developed to reflect topics that should be of interest to a student taking an introductory class. Four specific self-directed learning modules were developed and implemented in the topic material:

Number Systems: Base 10, 2, 8, 16
Preferred Learning Styles: Testing, Assessment, Reflection
Being a Master Student: Characteristics and Goal Setting
Using Excel to Make Charts

Student response to these modules has been very positive. Feedback from the students in the class will be used to improve the module materials. In each of the modules, students are asked to review a new concept that is presented, use the new concept to solve problems, assess their understanding of the learned concept, and provide feedback to the instructor that they understand the concept, or need more time to have questions answered about the concept. The module material is presented over a series of weeks to allow feedback as each component is covered.

The Group Project's objectives are: to gain a better understanding of local companies that hire engineering/technologists and to identify the work duties that an engineering/technologist performs for his/her chosen company; to compile a list of special skills that are essential to the engineering/technologist's success; to appreciate the variety of tasks engineering technologists engage in on a daily basis at their job and in the community. A written report, summary table, and final oral presentation including a power point presentation (not to exceed 30 slides) is part of this project. Each week each student has an individual project to work on, as well. These projects have included identifying characteristics of good resumes, collecting data for a resume, writing a resume, interview techniques, and writing a biographical sketch.

Functionally, quizzes are posted on a Wednesday and are to be delivered for grading by Sunday evening at 9:00 PM of the same week. The materials are graded and grades posted, normally by Tuesday, and the cycle starts again. Group projects are graded using an assessment tool given to the student at the beginning of the course based upon criteria discussed in the project overviews. Providing this tool to students has significantly improved the quality of papers and presentations submitted. Any document submitted for grading by a student must include a statement signed and dated by the student that "They did not have an unfair advantage over other students in the class and that they performed all tasks within the time constraints given for a particular assignment."

Stage One at Binghamton - The DTeC Program

The DTeC program, which integrates instruction in communications, computers, graphics and design, provides a natural platform for developing SDL skills and attitudes.[10] The class meets three times a week for two hours. The first 20 minutes is a general session with approximately 75 students. Following the general session, students attend one of three labs: communications, computers, or graphics/design. The general session provides an opportunity to describe the rationale behind the SDL exercises. Guest speakers as well as DTeC instructors are used to lay the groundwork for a series of exercises that are incorporated into the class work in the three labs. The first semester focuses on some of the basic skills required for SDL: time management, goal setting , study skills, and the process for monitoring progress in these areas. In the second semester the students use these concepts to design elements of their instructional activities, including an evaluation and grading plan.

At the beginning of the fall semester, the Communications component of DTeC emphasizes teamwork. Students are put in teams the first week of class to work on the mechanical dissection engineering design project.[11] Communications emphasizes through theory and practice the importance of developing this life-long skill. For

students not accustomed to working in teams, early team experiences often seem very awkward, vague, and confusing. In fact, some activities have made students so uncomfortable that, at first, they try to avoid team experiences. During the second design project - creation of a multimedia program to describe a scientific concept to fourth graders [12] - students are put into new teams and experience the teaming process with the student maintaining responsibility for learning while sharing control with the teacher. Students also engage in activities that emphasize the importance of decision by consensus and how to conduct an effective meeting. Two forms - Documentation and Assessment of Project Team Meeting and Post Meeting Reaction - have been created, based on a model used at Colorado School of Mines.[13] These forms are vital to the ongoing monitoring of student's progress as they work in teams. These forms are submitted weekly by student teams. The forms are easy to read and become the basis for teacher intervention.

In DTeC, emphasis in put on the study skills needed for SDL. The instructors devote some of their 20 minute General Sessions to workshops on Time Management, Goal Setting, and Attitude and Motivation. Each workshop requires a follow-up assignment that each student has to complete and review in Communications Lab. Self teaching modules are being developed for all of the basic study skills, which students can use based on their weaknesses and needs. The modules will take into account the current theory of self-directed learning and be formatted in such a way to help the student identify the starting point for a learning project and discern relevant modes of self-assessment and reporting. Formats and follow-through strategies are currently being researched to enable the DTeC staff to formalize these modules for fall 2000.

In DTeC Communications, students develop professional presentation and writing skills. In the fall semester, students give two formal oral presentations at the end of the engineering design projects. The presentations, which are called post mortem reports, provide an opportunity for students to reflect on what they are learning, an essential self-directed skill. Student teams make the presentations. After receiving specific criteria for the presentations and information about what constitutes a good presentation, students are responsible for putting together a format, structuring their time for preparing and rehearsing. Outside help is offered when requested by the project groups.

This process is carried over into the spring semester. Students have their individual grade and comment sheets from the fall semester and are asked to design a learning project for the semester that will strengthen their presentation skills. They can select any topic or mode of communication for this creative writing project. Based on the experience at BCC, a web page has been developed which allows students to submit their work electronically and evaluate their status in the project.

The same format is used in the student's writing portfolios that was begun in the fall semester. A partnership is created with the student by negotiating a learning contract for goals, strategies, and evaluation criteria. If the process functions correctly, students learn inquiry skills, decision making, know how to self evaluate their work, and develop positive attitudes and feelings of independence relative to learning. This self-directed process encourages critical thinking skills by incorporating seminars and workshops into the classroom and creating an atmosphere of openness and trust to promote better performance. Upperclassmen, serving as course assistants, give individual attention to the freshmen students and provide special tutelage when needed. The final evaluation is an extensive presentation of their culminating engineering design project, the design and construction of an assistive device for a client with disabilities.[14]

One of the immediate concerns of SDL instruction is the effort it takes to maintain the motivational levels of students. Students are initially motivated because they are in charge of selecting the content and methodology of their writing projects. The challenge to the instructor is maintaining the motivation to get the job done. Students begin enthusiastically, but when they discover it is not as easy as they first imagined, they begin to give up. It is essential that either the teacher or the course assistant intervene to bring them back on track. This can be done as a whole class or with individual students.

It is key to catch all problems as soon as possible. When you are working with large numbers of students this becomes difficult. The solution is to create a structure and format that keeps track of the information needed to track each student's progress in the process. Because students develop their own contracts they are working at individual levels and at the pace that is comfortable to them, but at the same time challenges them. When you are in a lab with 23 students who are all working on different projects, it is essential to redesign lectures and whole class exercises so that they apply to all students' projects.

One student criticism of SDL theory is that there is a lack of structure and format, and that it is a way for a teacher to sit back and let the student do all of the work. Anyone who puts together a SDL program realizes that it is much harder than the traditional approach where the teacher controls everything. One of the most difficult tasks is managing the individual

projects in such a way that each student knows and understands where he/she is in the process, and what needs to be done next. A second problem for the teacher is being able to easily pull out a file that records every step in the student's process in order to accurately assess each student's progress. The task we are undertaking now is to develop a structure and format that manages the recording of information for each student in his or her projects.

Conclusion

Responsibility and control of learning are fundamental to SDL as well as the development of critical thinking. All learning can and should be viewed as a continuum, parallel with the timeline of one's life. Life-long learning, whether it is complex, formal, or incidental, is a continuous process, dependent on that is has its roots in self-directness. SDL must begin in the freshman year to set in motion the energy with which self-direction begins to perpetuate itself. Students gain confidence in their ability to learn, which in turn tends to drive them to experience additional learning situations which they might otherwise have avoided or even considered impossible, as in the teaming experience. When self-directed learning is employed, the whole person develops and the learning goals of the college are advanced. Joint development and the sharing of experiences has assisted both colleges in this project in building more effective programs.

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Table 1 - The Staged Self-Directed Learning Model

	Student	Teacher	Examples
Stage 1	Dependent	Authority, Coach	Coaching with immediate feedback. Informational lecture. Overcoming deficienc and resistance
Stage 2	Interested	Motivator, Guide	Inspiring lecture plus guided discussion. Goal-setting and learning strategies.
Stage 3	Involved	Facilitator	Discussion facilitated by teacher who participates as equal. Seminar. Group projec
Stage 4	Self-Directed	Consultant delegator	Internship, dissertation, individual work or self-directed study-group.

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